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EVALUATION OF HYDROLOGIC PROCESSES AFFECTING SOIL MOVEMENT IN THE HAGERMAN FAUNA AREA, HAGERMAN, IDAHO

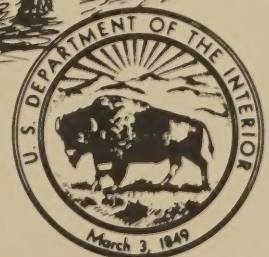
U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 84-4137

Prepared in cooperation with the
U.S. BUREAU OF LAND MANAGEMENT



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By H. W. Young

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CONVERSION FACTORS

For readers who prefer to use metric units, conversion factors for units used in this report are listed below.

<u>Multiply</u>	<u>By</u>	<u>To obtain</u>
acre	4,047	square meter
acre-foot (acre-ft)	1,233	cubic meter
cubic foot per second (ft ³ /s)	0.02832	cubic meter per second
foot (ft)	0.3048	meter
gallon per minute (gal/min)	0.06309	liter per second
inch (in.)	25.40	millimeter
mile (mi)	1.609	kilometer
square mile (mi ²)	2.590	square kilometer

NGVD of 1929 (National Geodetic Vertical Datum of 1929):
The term "National Geodetic Vertical Datum of 1929" replaces the formerly used term "mean sea level" to describe the datum for altitude measurements. The geodetic datum is derived from a general adjustment of the first-order leveling networks in both the United States and Canada. For convenience in this report, the datum also is referred to as "sea level."

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ABSTRACT

The Hagerman fauna area on the western slope of the Snake River canyon in south-central Idaho is one of the most important locations of upper Pliocene fossils in the world. The fossil beds are distributed vertically through a 500-foot stratigraphic section of the Glens Ferry Formation.

Accelerated soil movement caused by surface-water runoff from irrigated farmlands on the plateau above the canyon and discharge from springs and seeps along the slope of the canyon is eroding the fossil beds. Source of the springs and seeps is a perched aquifer, which is probably recharged by seepage losses from two irrigation canals that head near the canyon rim. Annual canal losses are about 1,900 acre-feet. Annual discharge from springs and seeps is about 420 acre-feet.

Corrective measures that could be taken to stabilize the soil movement and preserve the fauna area include: (1) Lining or treating the canals, (2) eliminating the practice of flushing irrigation systems, (3) constructing road berms and cross dips, and (4) establishing an uncultivated strip of land between irrigated farmlands and the canyon rim.

Future study of the nature and extent of the perched aquifer would help determine the amount of canal lining or treatment needed to effectively reduce recharge to the springs. A monitoring network of wells and springs would determine seasonal and long-term trends in water-level fluctuations and spring discharges.

INTRODUCTION

The Hagerman fauna area encompasses about 8.5 mi² and is one of the most important locations of upper Pliocene fossils in the world. The area is located along the western slope of the Snake River canyon about 2 mi west of Hagerman (fig. 1). The fossil beds are distributed vertically through a 500-ft stratigraphic section of the Glens Ferry Formation.

Currently (1983), accelerated soil movement, which has been identified at 33 sites in the fauna area, is destroying the scientific and educational value of the fossil beds. The soil movement is caused by surface-water runoff from sprinkler-irrigated farmlands on the plateau above the canyon and by discharge from springs and seeps along the canyon slope.

Hydrologic processes governing water sources and movement must be understood so corrective measures can be taken to preserve the fauna area.

Purpose and Scope

Purposes of this study were to: (1) Describe the accelerated soil movement, (2) define the ground-water hydrology, (3) identify the causes of soil movement, and (4) suggest corrective measures that could stabilize present rates of soil movement and prevent future soil movement.

The major emphasis of this study was on collection of hydrologic data pertinent to the soil movement problem. Scope of the study included (1) mapping locations of springs, seeps, and sites of major soil movement; (2) studying seepage losses from 2 irrigation canals; (3) measuring or estimating surface-water runoff and ground-water discharge; (4) inventorying 12 springs and 1 well; and (5) analyzing data and completing a report describing results of the study.

Well- and Spring-Numbering System

The well- and spring-numbering system (fig. 2) used by the U.S. Geological Survey in Idaho indicates the location of wells or springs within the official rectangular subdivision of public lands, with reference to the Boise base

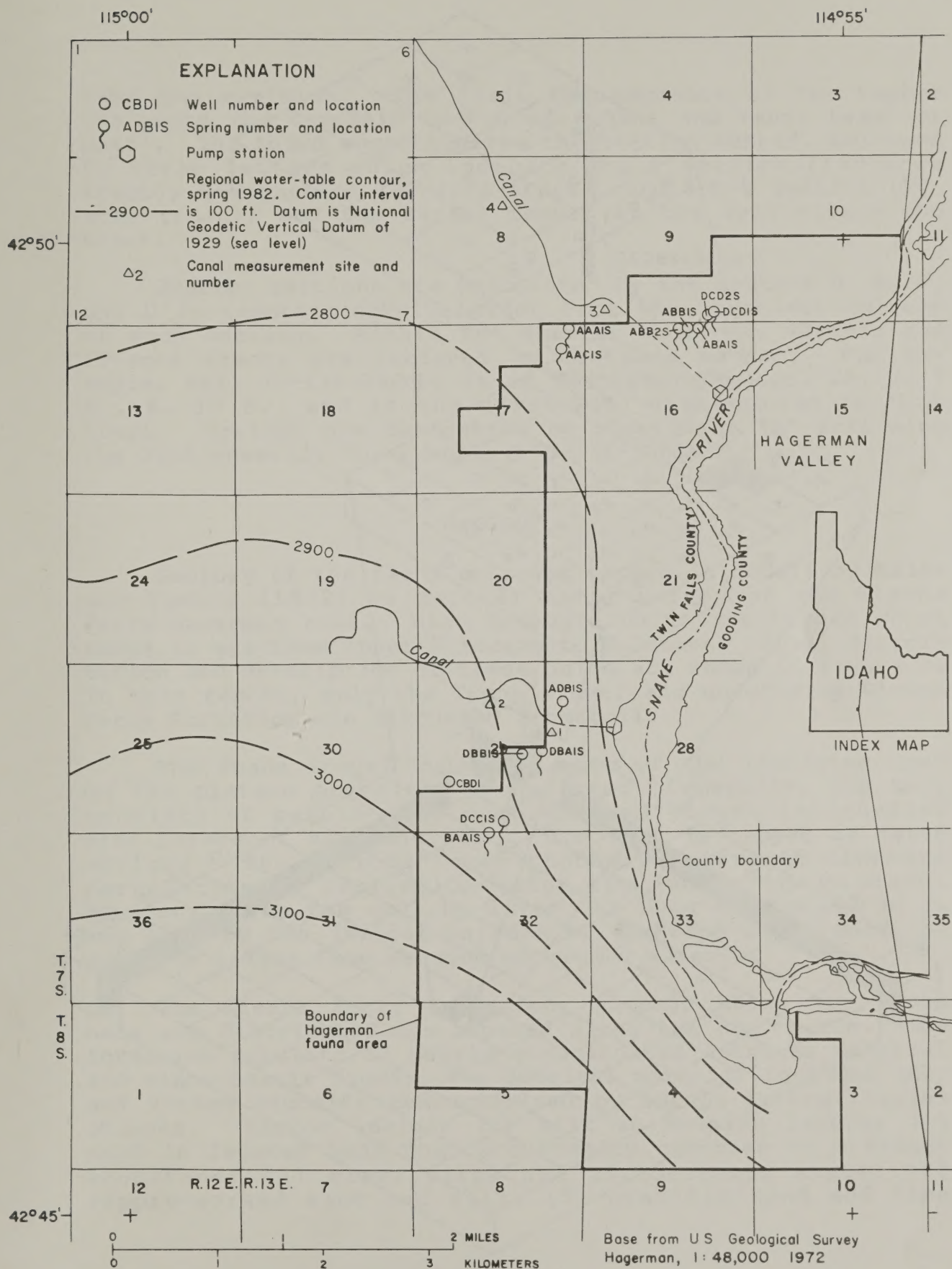


Figure 1.--Regional water-table contours and locations of data-collection sites.

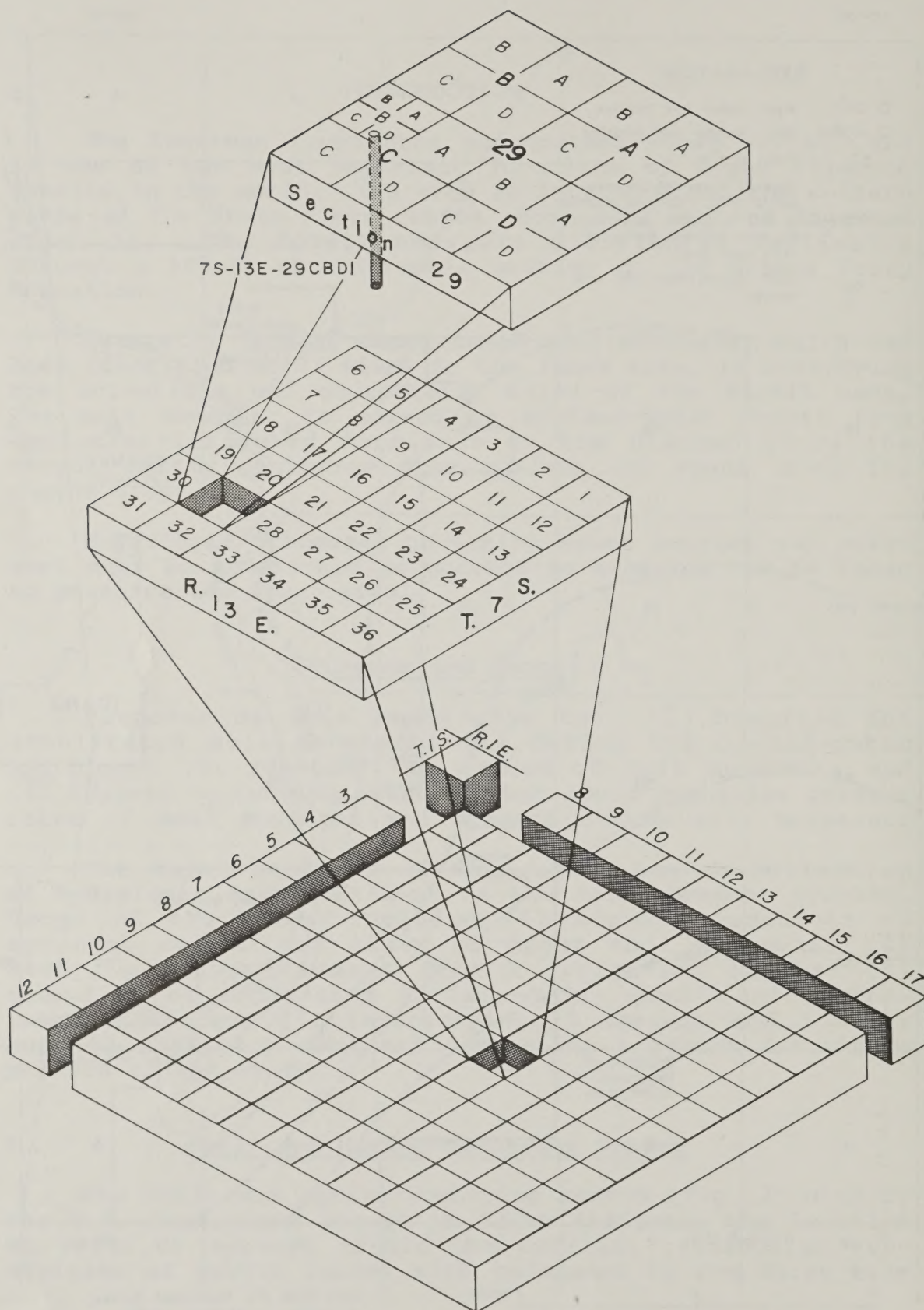


Figure 2.--Well- and spring-numbering system.

line and meridian. The first two segments of the number designate the township (north or south) and range (east or west). The third segment gives the section number, followed by three letters which indicate the $\frac{1}{4}$ section (160-acre tract), $\frac{1}{4}$ - $\frac{1}{4}$ section (40-acre tract), and $\frac{1}{4}$ - $\frac{1}{4}$ - $\frac{1}{4}$ section (10-acre tract); and the serial number of the well within the tract.

Quarter sections are designated by the letters A, B, C, and D in counterclockwise order from the northeast quarter of each section. Within the quarter sections, 40-acre and 10-acre tracts are lettered in the same manner. For example, well 7S-13E-29CBD1 is in the SE $\frac{1}{4}$ NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 29, T. 7 S., R. 13 E., and is the first well inventoried in that tract. Springs are designated by the letter "S" following the last numeral; for example, 7S-13E-16ABB1S.

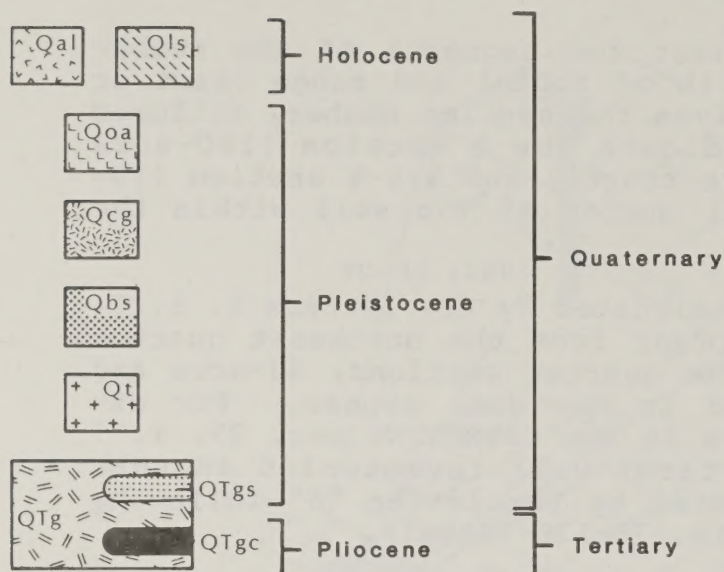
GEOLOGY

Geology of the fauna area was mapped in detail by Malde and Powers (1972) as part of their survey of the Glenns Ferry-Hagerman area. Nine geologic units are mapped which range in age from upper Pliocene to Holocene. Areal distribution and description of these units are shown in figure 3. In this report, only the Tuana Gravel and underlying Glenns Ferry Formation are discussed in detail.

The Tuana Gravel underlies most of the irrigated land on the plateau above the fauna area. Generally, the unit consists of pebble- and cobble-sized gravel interbedded with layers of sand and silt. The unit is capped by dense caliche. The caliche layer probably restricts downward percolation of irrigation water applied on the plateau. However, where the caliche layer has been disrupted, as it has been by two irrigation canals, downward percolation of water is likely (see section on ground water).

The Glenns Ferry Formation, through which the fauna beds are distributed, is exposed along the canyon rim. The formation consists of poorly consolidated detrital material and minor basalt flows. The detrital material includes lake and stream deposits characterized by abrupt lateral facies changes. Facies include (1) silt in massive layers; (2) sand in layered beds that are locally cemented to a flaggy sandstone; (3) clay, silt, and carbonaceous shale; (4) ripple-marked sand and silt; (5) granitic sand and fine

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS



STREAM ALLUVIUM



LANDSLIDE DEBRIS



OLDER ALLUVIUM - chiefly terrace deposits of pebble and cobble gravel



CROWSNEST GRAVEL - chiefly silicic volcanic pebbles



BRUNEAU FORMATION - sedimentary material consisting of lakebeds of silt, clay, and diatomite



TUANA GRAVEL - pebble and cobble gravel interbedded with sand and silt



GLENN'S FERRY FORMATION - poorly consolidated detrital basin-fill deposits consisting of clay, silt, sand, and gravel

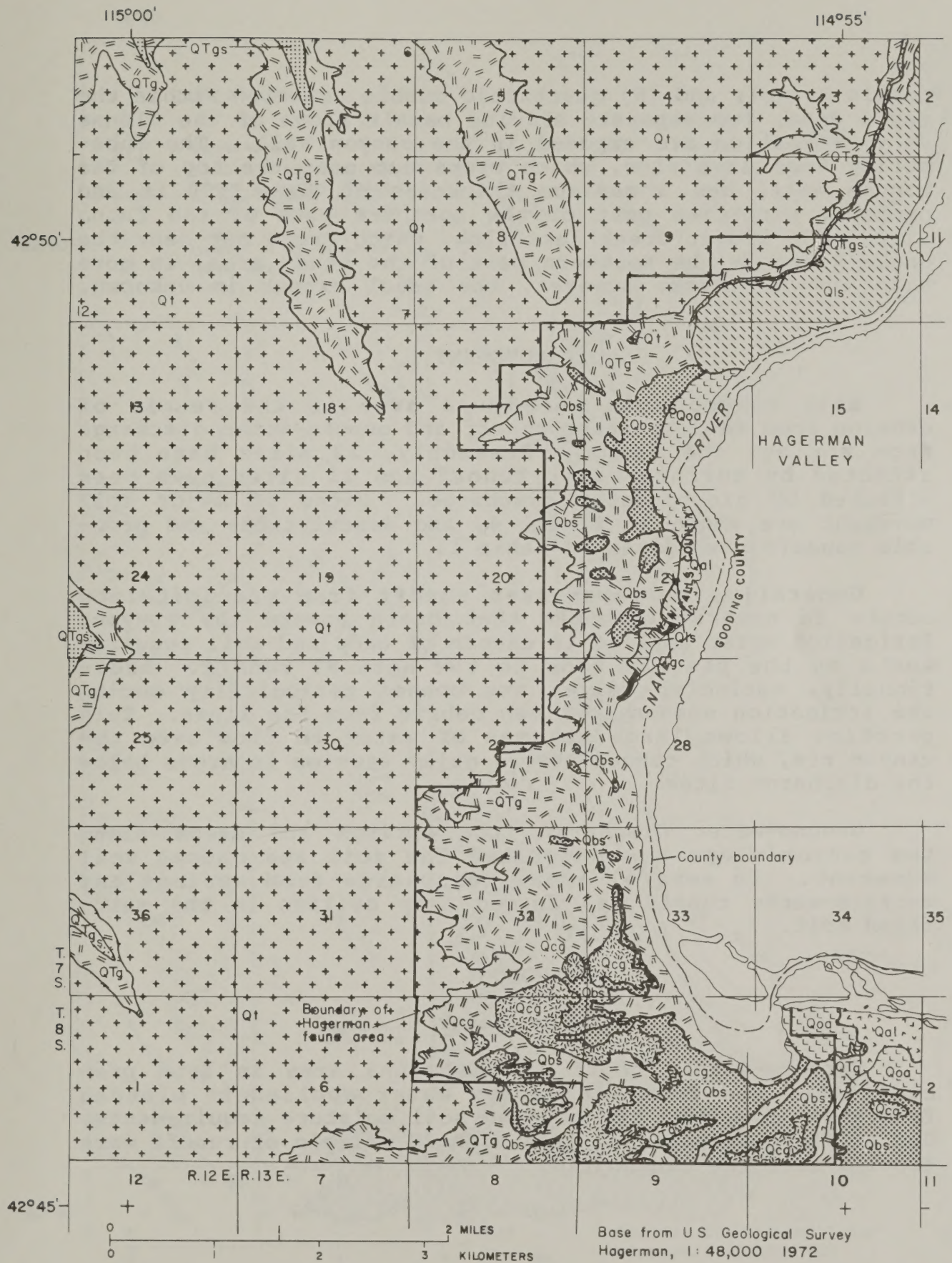


Shoestring Road lava flow - porphyritic olivine basalt



Clover Creek lava flow - aphanitic olivine basalt

Figure 3.--Geology of the



Hagerman fauna area.

pebble gravel; and (6) quartzitic cobble gravel. Within the fauna area, two separate olivine basalt flows of the Glenns Ferry Formation are exposed in the canyon wall. The Shoe-string Road lava flow, which crops out near the top of the canyon wall, has a maximum thickness of about 100 ft and probably underlies most of the northern part of the fauna area. The Clover Creek lava flow, which crops out near the Snake River in the southern part of the study area, is more than 100 ft thick; however, the areal extent is unknown.

SOIL MOVEMENT

Soil movement in the fauna area is the result of erosion from surface-water runoff and ground-water discharge from springs and seeps. Presently, 22 sites have been affected by surface-water runoff and 11 sites have been affected by ground-water discharge. Sites of major soil movement are shown in figure 4, and descriptions and probable cause(s) are given in table 1.

Generally, surface-water runoff from precipitation occurs in natural channels that drain toward the canyon. Irrigation water applied in excess of crop and soil requirements on the plateau adds to the natural runoff. Additionally, sprinkler valves are opened periodically during the irrigation season to flush debris from the lines. This practice allows large volumes of water to flow over the canyon rim, which causes severe gully erosion in areas below the discharge sites.

Ground-water discharge from springs and seeps along the canyon slope has saturated the soil and caused soil movement. In several areas, discharge from springs and surface-water runoff has formed deep gullies in the saturated soil.

HYDROLOGY

Surface Water

Surface-water runoff in the fauna area is from precipitation and from irrigation water applied to plateau farmlands in excess of crop and soil moisture requirements. During field inspection, less than 20 gal/min of runoff were flowing over the canyon rim.

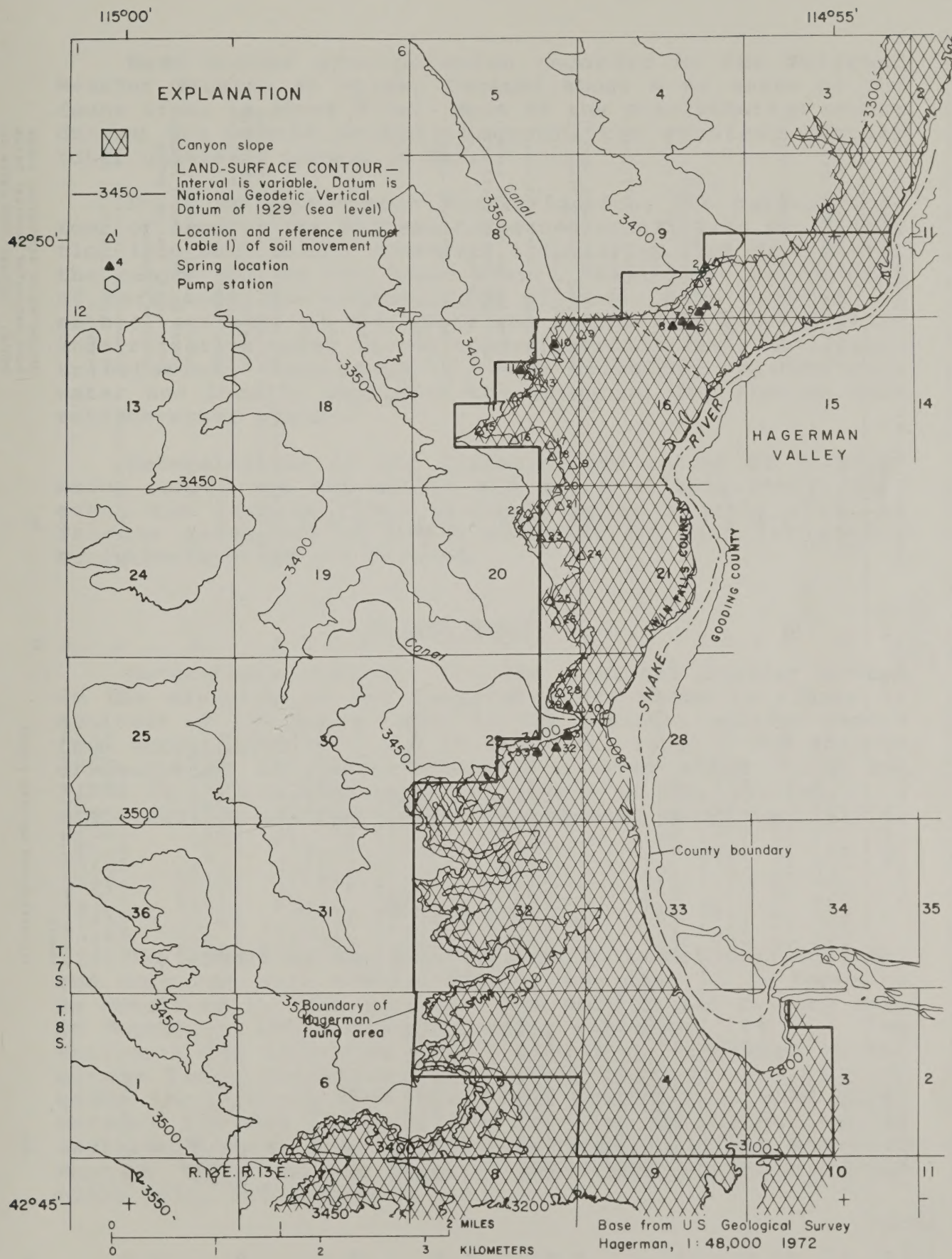


Figure 4.--Sites of major soil movement.

Table 1.--Description and causes of soil movement

Site number (location shown in fig. 4)	Description of soil movement	Cause(s) of soil movement	Site number (location shown in fig. 4)	Description of soil movement	Cause(s) of soil movement
1	Gully erosion	Irrigation runoff. Broken mainline in sprinkler system; pipe has been repaired	14	Gully erosion	Irrigation and natural runoff. Powerline access road acts as a collector
2	do.	Natural drainage. Irrigation and natural runoff	15	do.	Irrigation and natural runoff
3	Gully erosion, large washouts	Irrigation runoff. Most erosion occurs when valve in main sprinkler line is opened to flush system	16	do.	Do.
4	Soil slump or creep below springs. Soil creep has filled natural channel. Springs have cut new channels through slumping material	Ground-water discharge. Springs have saturated material below vents	17	do.	Do.
5	do.	Do.	18	do.	Irrigation runoff. Most erosion occurs when valve in main sprinkler line is opened to flush system
6	Soil slump or creep below spring, gully erosion below spring	Ground-water discharge. Spring has saturated material below basalt outcrop. Some gully erosion below spring due to surface-water runoff	19	do.	Natural runoff, possibly some irrigation runoff
7	do.	Do.	20	do.	Irrigation and natural runoff; access road to Snake River acts as a collector
8	Soil slump or creep below springs. Large gully erosion below springs	Ground-water discharge. Springs have saturated material below basalt outcrop. Most of the large gullies due to surface-water runoff	21	do.	Irrigation and natural runoff
9	Gully erosion	Irrigation runoff. Most erosion occurs when valve in main sprinkler line is opened to flush system. A pipe under road collects irrigation runoff, which adds to surface-water runoff	22	do.	Irrigation and natural runoff; road along edge of field acts as a collector
10	Soil slump or creep below spring, some gully erosion below spring	Ground-water discharge. Spring has saturated material below vent. Some movement due to gully erosion from surface-water runoff	23	do.	Irrigation and natural runoff
11	do.	Do.	24	do.	Do.
12	Gully erosion	Irrigation runoff. Most erosion occurs when valve in main sprinkler line is opened to flush system. Some erosion due to natural and irrigation runoff	25	do.	Do.
13	do.	Irrigation and natural runoff	26	do.	Do.
			27	do.	Do.
			28	do.	Do.
			29	Soil slump or creep; some gully erosion	Ground-water discharge. Springs have saturated material below vents. Some movement due to gully erosion from surface-water runoff
			30	Gully erosion	Natural runoff; probably enhanced by roads around communication relay station, which act as a collector
			31	Soil slump or creep	Ground-water discharge; seeps have saturated material below vents
			32	do.	Do.
			33	do.	Ground-water discharge; seeps have saturated material below vents. Leakage from valve in sprinkler line may add to saturation of material near slump

Mean annual precipitation recorded by the National Weather Service at Bliss, located about 6 mi north of the fauna area, is about 9 in. Most of the precipitation occurs during the winter months; however, the greatest monthly total generally occurs in May.

Prior to development for irrigation, the natural contour of land on the plateau dispersed runoff from precipitation into many small, ephemeral tributaries that flowed over the canyon rim to the Snake River. Subsequent development of farmlands and construction of roads have altered the natural contours of the land, and runoff from precipitation and irrigation water is now concentrated in fewer but larger tributaries. Consequently, each tributary carries more water and locally amplifies the potential for erosion from surface-water runoff.

Determination of the frequency and volume of surface-water runoff was not within the scope of this study; however, the largest flows probably occur shortly after an intense rainstorm or rapid snowmelt or when irrigation sprinkler systems are flushed.

Ground Water

Water-table contours for the regional aquifer system in the vicinity of the fauna area are shown in figure 1. Altitude of the water table in the regional aquifer ranges from about 2,800 to 2,900 ft above sea level. The springs discharge at altitudes generally between about 3,100 and 3,200 ft, which indicates the source of the springs is a minor aquifer perched above the regional water table (fig. 1).

Occurrence

The extent of the perched aquifer is not well defined, and only one well (7S-13E-29CBD1, see fig. 1) is known to be completed in this aquifer. The well is 245 ft deep and, in September 1983, depth to water was about 139 ft. The driller's log indicates that the well is completed in the Glens Ferry Formation. The water-bearing zone is just below the contact with the Tuana Gravel in a sand layer between 150 and 161 ft. The log also indicates that no additional water was encountered during drilling and that most of the remaining material penetrated was fine-grained clay, silt, and sandstone.

Source

Prior to development of farmlands on the plateau and construction of two irrigation canals supplied by water pumped from the Snake River and lifted to the canyon rim (fig. 1), the springs and seeps on the canyon slope did not exist. Therefore, the principal source of recharge to the perched aquifer that feeds the springs and seeps is probably seepage losses from the canals. Other possible sources of recharge include infiltration of applied irrigation water and precipitation.

Some recharge is probably by infiltration of irrigation water applied in excess of crop requirements and evaporation; however, owing to the efficiency of sprinkler irrigation, the amount is probably small.

Recharge to the perched aquifer from about 9 in. average annual precipitation on the plateau above the fauna beds is probably minimal (Sondregger, 1929, p. 1164).

Streamflow measurements along the irrigation canals are given below (see fig. 1 for locations of measuring sites):

<u>Site No.</u>	<u>Discharge, in cubic feet per second</u>
1	52.1
2	50.4
Estimated loss per mile is 3.3 ft ³ /s, or 6 percent	
3	71.5
4	66.9
Estimated loss per mile is 4.6 ft ³ /s, or 6 percent	

Assuming a 120-day irrigation season, annual canal losses for a 1-mi reach near the fauna area total about 1,900 acre-ft.

Discharge

Water is discharged from the perched aquifer by underflow, springs, and pumping. Much of the water probably moves as underflow to the west or northwest away from the canyon rim. Springs in sections 9 and 16 issue from the top of the Shoestring Road basalt flow, which impedes the downward movement of water. The remaining springs issue from sedimentary material in the Glenns Ferry Formation near the contact with the Tuana Gravel.

Discharge measurements for springs in the fauna area are given below (e, estimated; --, no data; r, reported):

<u>Spring No.</u>	<u>Discharge, in gallons per minute</u>
7S-13E- 9DCD1S	11
9DCD2S	23
16ABA1S	18
16ABB1S	6
16ABB2S	76
17AAA1S	61
17AAC1S	28
29ADB1S	25e
29DBA1S	--
29DBB1S	--
29DCC1S	--
32BAA1S	15r

Assuming a constant rate of flow, annual discharge from springs and seeps in the fauna area is about 420 acre-ft. However, ground-water discharge is probably greater than this, evidenced by additional seeps, wetted ground, and evaporite deposits noted around the springs. Discharge from the perched aquifer by pumping and underflow is unknown. However, pumping probably is small because only one well is completed in the perched aquifer. Underflow could not be estimated owing to insufficient data.

SUGGESTIONS FOR CORRECTIVE MEASURES

Accelerated soil movement in the fauna area is the result of surface-water runoff and ground-water discharge from springs. Following are corrective measures that, if implemented, could stabilize present rates of soil movement and prevent future soil movement:

1. Lining or otherwise treating the two irrigation canals to reduce seepage losses would eliminate the principal source of recharge to the perched aquifer.
2. Eliminating the practice of flushing irrigation sprinkler systems adjacent to the canyon rim would halt the severe erosion in areas below the valves.
3. Constructing berms and cross dips on all roads in and adjacent to the fauna area would reduce the rate of erosion from surface-water runoff.

4. Establishing an uncultivated strip of land between irrigated farmland and the canyon rim would reduce the amount of surface-water runoff and hence reduce soil erosion.

Implementing corrective measure 1 would reduce soil movement that is the result of ground-water discharge at 11 sites. Implementing corrective measures 2, 3, and 4 would reduce soil movement that is the result of surface-water runoff at 22 sites.

FUTURE STUDIES

Although some interpretations are discussed in this report, they are based on minimum data; as in all reconnaissance studies, collection of additional data could improve results. Future work needed to enhance the findings in this study would include installing test holes and acquiring and interpreting new data to better define the perched aquifer. Major items future work could address are: (1) Defining areal and vertical extent of the perched aquifer, (2) determining the hydraulic gradient and location of a ground-water divide in the perched aquifer, (3) monitoring water-level fluctuations in the perched aquifer, and (4) monitoring ground-water discharge from the perched aquifer.

A ground-water divide in the perched aquifer probably separates ground-water movement toward the canyon rim from movement to the west or northwest. The areal extent and hydraulic gradient of the perched aquifer must be known to adequately determine the amount of canal lining or treatment needed to effectively reduce recharge to the springs. In addition to the areal extent, knowledge of the vertical extent of the aquifer is necessary to estimate the total volume of water in the aquifer. A number of strategically placed test holes would more accurately define the areal and vertical extent of the perched aquifer and the location of the ground-water divide.

A monitoring network of wells and springs would determine seasonal and long-term trends in water-level fluctuations and spring discharge. Implementation of the monitoring network prior to canal lining would be valuable in assessing the effects of reduced recharge to the perched aquifer.

SUMMARY

The Hagerman fauna area in south-central Idaho is one of the most important locations of upper Pliocene fossils in the world. The site encompasses about 8.5 mi² along the western slope of the Snake River canyon near Hagerman.

The fossils are distributed through a 500-ft stratigraphic section of the Glens Ferry Formation, which is composed of poorly consolidated detrital material and minor basalt flows. This formation is overlain by the Tuana Gravel, which consists of pebble- and cobble-sized gravel interbedded with layers of sand and silt. The unit is capped by dense caliche.

Accelerated soil movement is destroying the scientific and educational value of the fossil beds. The soil movement is caused primarily by surface-water runoff from sprinkler-irrigated farmlands on the plateau above the canyon and by discharge from springs and seeps along the canyon slope.

Surface-water runoff from precipitation occurs in natural channels that drain toward the canyon. Irrigation water applied in excess of crop and soil moisture requirements on the plateau adds to the natural runoff. Additionally, sprinkler valves are opened periodically during the irrigation season to flush debris from the lines. This practice allows large volumes of water to flow over the canyon rim and causes severe gully erosion in areas below the discharge sites. Determination of the frequency and volume of surface-water runoff was not within the scope of this study; however, the largest flows probably occur shortly after an intense rainstorm or rapid snowmelt or when irrigation sprinkler systems are flushed.

Annual discharge of about 420 acre-ft from springs and seeps along the canyon slope has saturated the soil and caused soil movement. In several areas, discharge from springs and surface-water runoff have formed deep gullies in the saturated soil. The principal source of the springs and seeps is a perched aquifer, which is recharged by seepage losses from two irrigation canals that head near the canyon rim. Estimated annual canal losses total about 1,900 acre-ft.

Corrective measures that could stabilize present rates of soil movement and prevent future soil movement include:
(1) Lining or treating the canals to eliminate seepage

losses, (2) halting the practice of flushing irrigation systems near the fauna area, (3) constructing berms and cross dips on roads in and adjacent to the area, and (4) establishing an uncultivated strip of land between the irrigated farmlands and the canyon rim.

Future work needed to enhance the findings of this study would include acquisition and interpretation of new data to better define the nature and extent of the perched aquifer.

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Malde, H. E., and Powers, H. A., 1972, Geologic map of the Glenns Ferry-Hagerman area, west-central Snake River Plain, Idaho: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-696, scale 1:48,000, 2 sheets.

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